SUPPLEMENTARY MATERIAL

Accounting for prediction error when inferring subsurface fault slip

Zacharie Duputel[1*], Piyush S. Agram[1+], Mark Simons[1], Sarah E. Minson[1] and James L. Beck[2]

[1] Seismological Laboratory, California Institute of Technology, Pasadena, USA.

[2] Division of Engineering and Applied Science, California Institute of Technology, Pasadena, CA, USA.

[*] Now at Institut de Physique du Globe de Strasbourg, UdS and EOST/CNRS UMR 7516, France.

[+] Now at Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA.

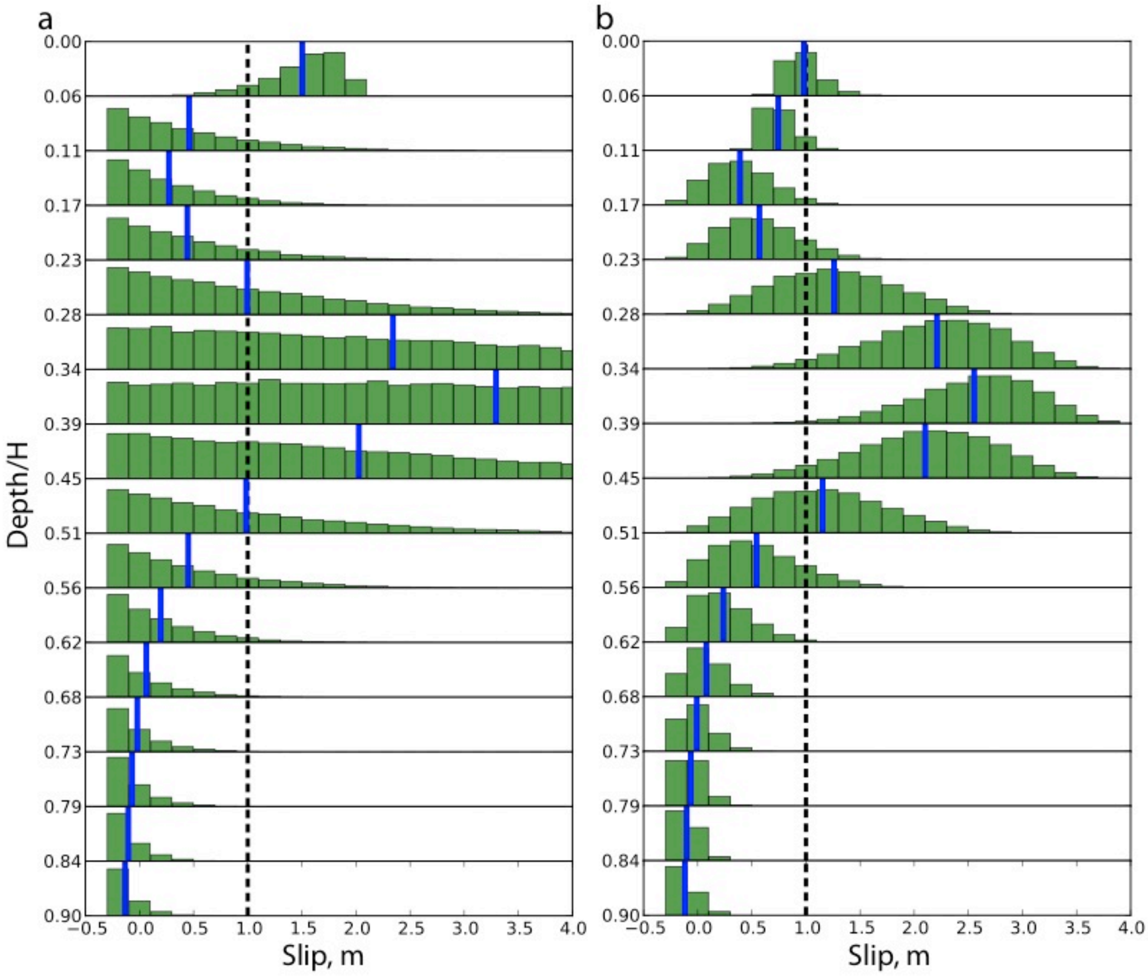

Figure S1. Source estimation for a constant unit slip distribution if $\mathbf{C}_p$ is neglected. The results obtained if $\mathbf{C}_p$ is included are presented in Fig. 4 of the main text. (a) Raw marginal PDFs for the slip in each fault patch. (b) Marginal PDFs using a moving average over 3 neighboring patches.

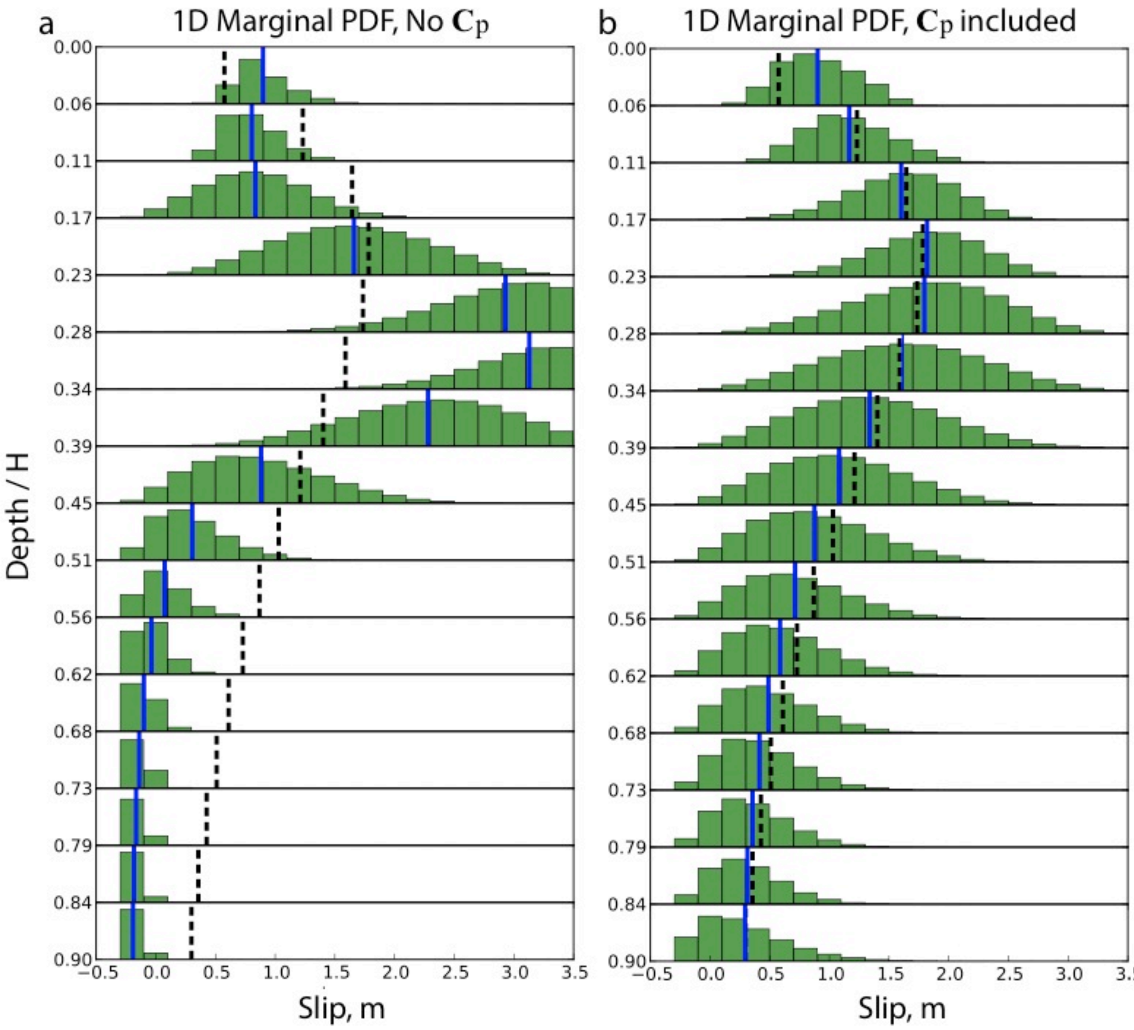

Figure S2. One-dimensional marginal posterior PDFs for each patch as a function of depth. The marginal probability density histograms are shown in green (a) when the prediction uncertainty is neglected and (b) when the prediction uncertainty is taken into account by including $\mathbf{C}_p$ in the inversion problem. The target slip model is indicated as dashed black lines and the mean of the distribution is shown in blue. The results in (b) are obtained using approach (2) described in section 4.4 of the main text: $\mathbf{C}_p$ is calculated at β=0 assuming a uniform unitary slip distribution as a function of depth (cf., model shown in Fig. S4 for β=0).

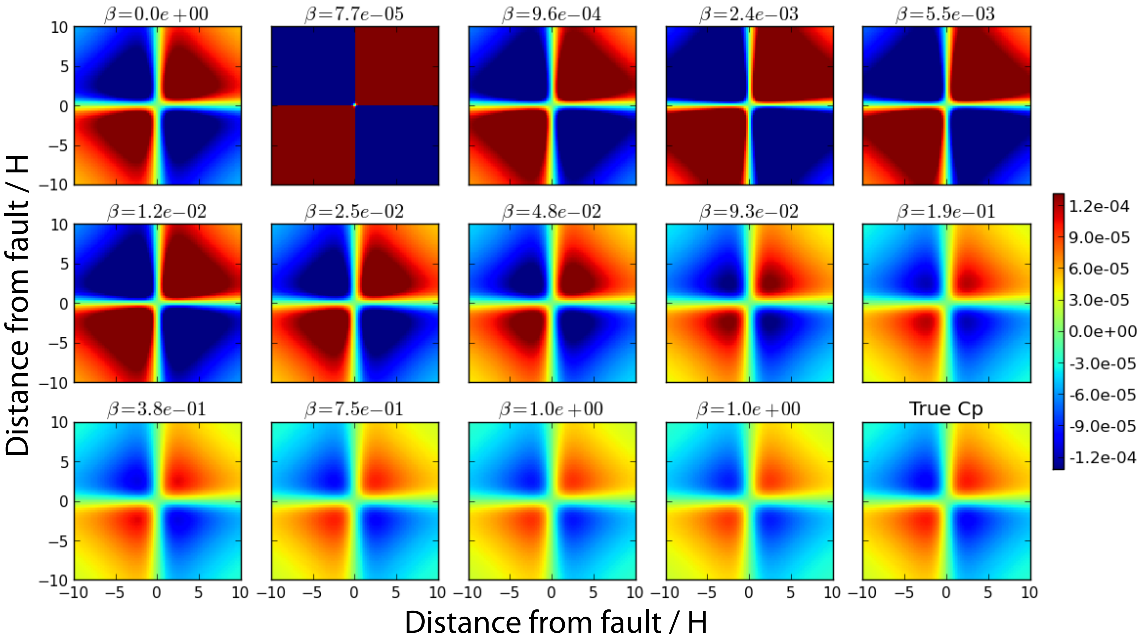

Figure S3. Evolution of the prediction covariance $\mathbf{C}_p$ at each transitional step. The approach (3) described in section 4.4 of the main text is used here: $\mathbf{C}_p$ is calculated at β=0 assuming a uniform unitary slip distribution as a function of depth (cf., model shown in Fig. S4 for β=0). The values of β are specified on top of each subfigures.

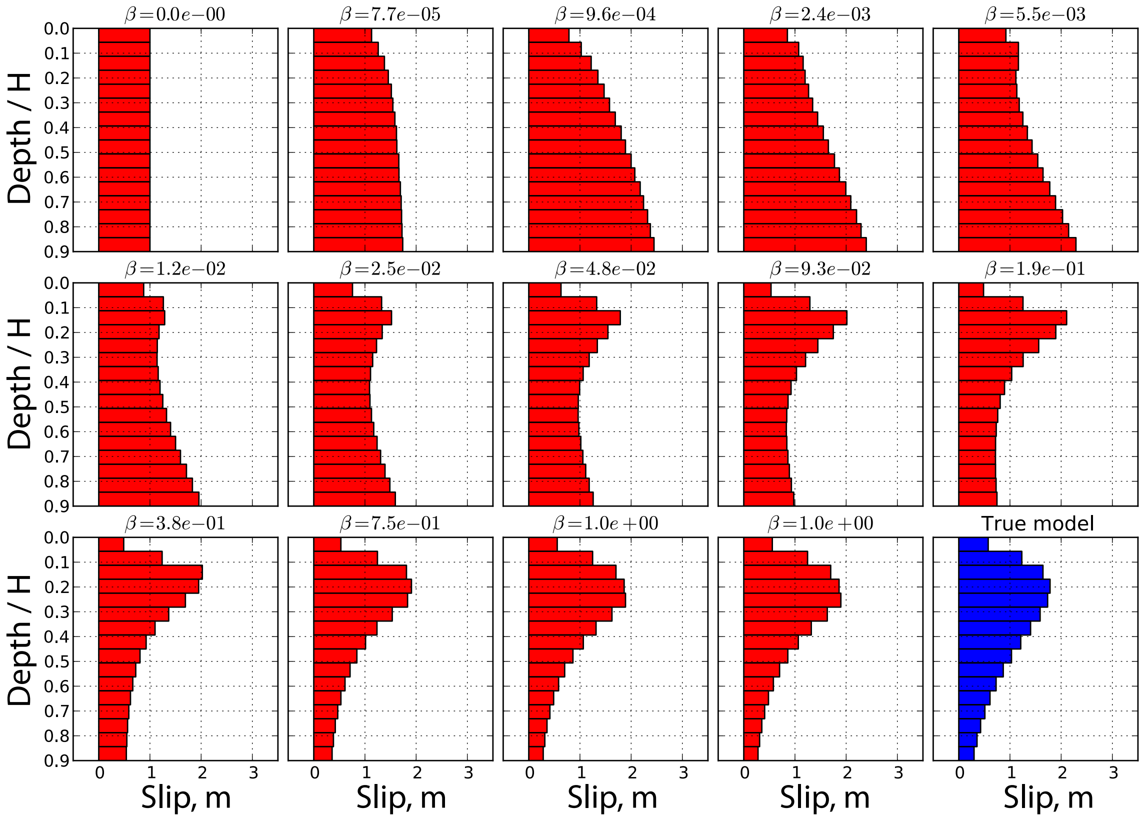

Figure S4. Slip models used for the calculation of the prediction covariance $\mathbf{C}_p$. The approach (3) described in section 4.4 of the main text is used here: the model used for the calculation of $\mathbf{C}_p$ at β=0 assuming a uniform unitary slip distribution as a function of depth (cf., model shown for β=0). These slip models correspond to the mean of the model sample distributions at each transitional step. The values of β are specified on top of each subfigures.

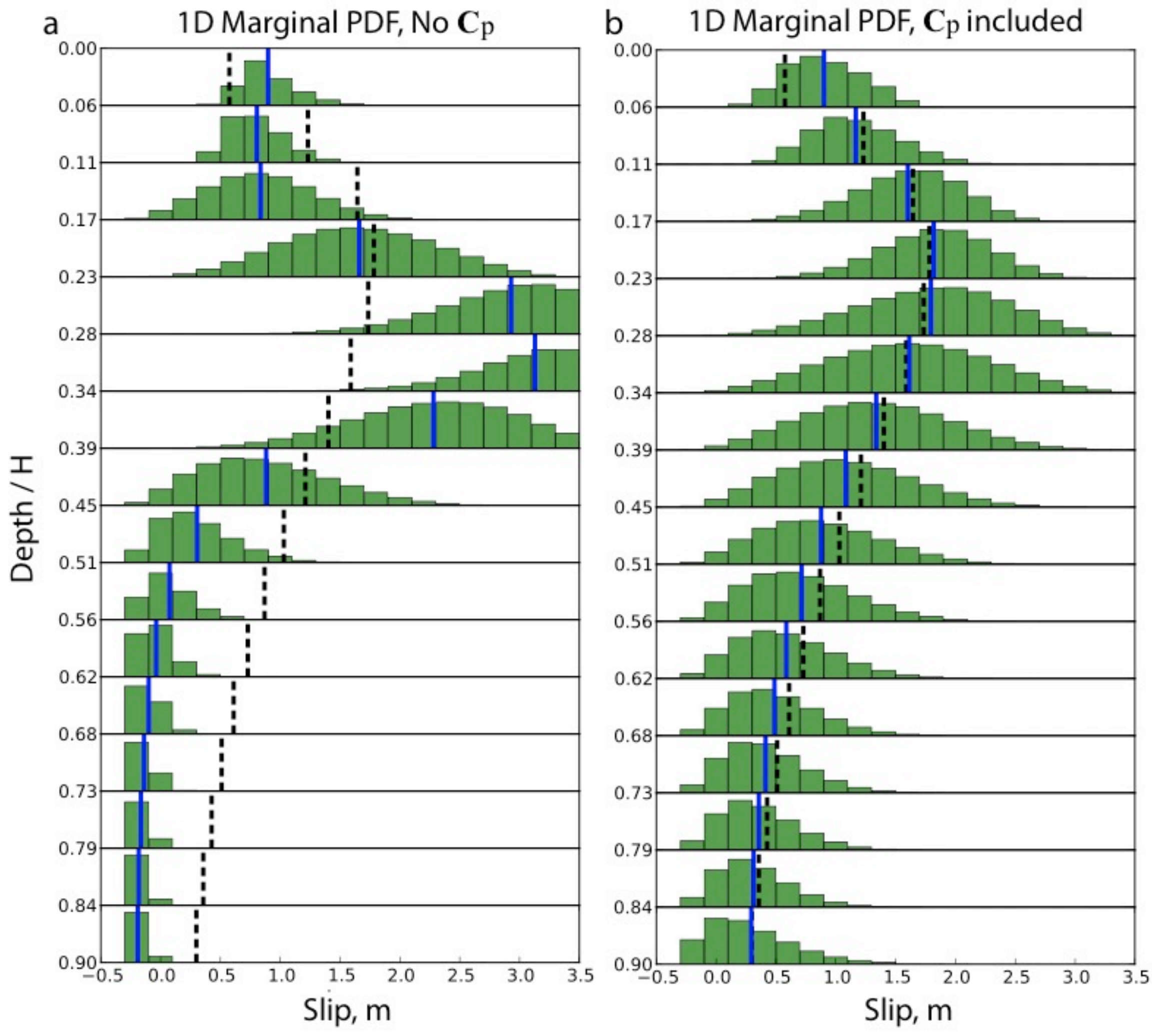

Figure S5. One-dimensional marginal posterior PDFs for each patch as a function of depth. The marginal probability density histograms are shown in green (a) when the prediction uncertainty is neglected and (b) when the prediction uncertainty is taken into account by including $\mathbf{C}_p$ in the inversion problem. The target slip model is indicated as dashed black lines and the mean of the distribution is shown in blue. The results in (b) are obtained using approach (3) described in section 4.4 of the main text: $\mathbf{C}_p$ is calculated at β=0 using the posterior mean model for which $\mathbf{C}_p$ is neglected (cf., blue bars in (a) and Fig. S7).

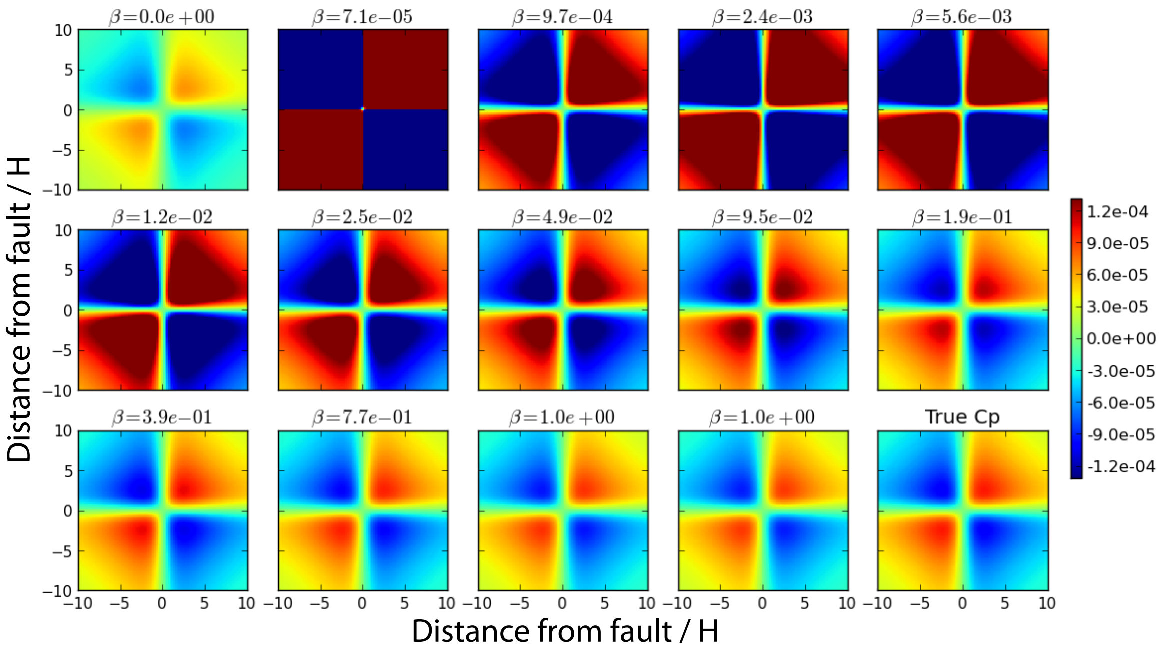

Figure S6. Evolution of the prediction covariance $\mathbf{C}_p$ at each transitional step. The approach (3) described in section 4.4 of the main text is used here: $\mathbf{C}_p$ is calculated at β=0 using the posterior mean model for which $\mathbf{C}_p$ was neglected (cf., Fig. S7 and blue bars in Fig. S5a). The values of β are specified on top of each subfigures.

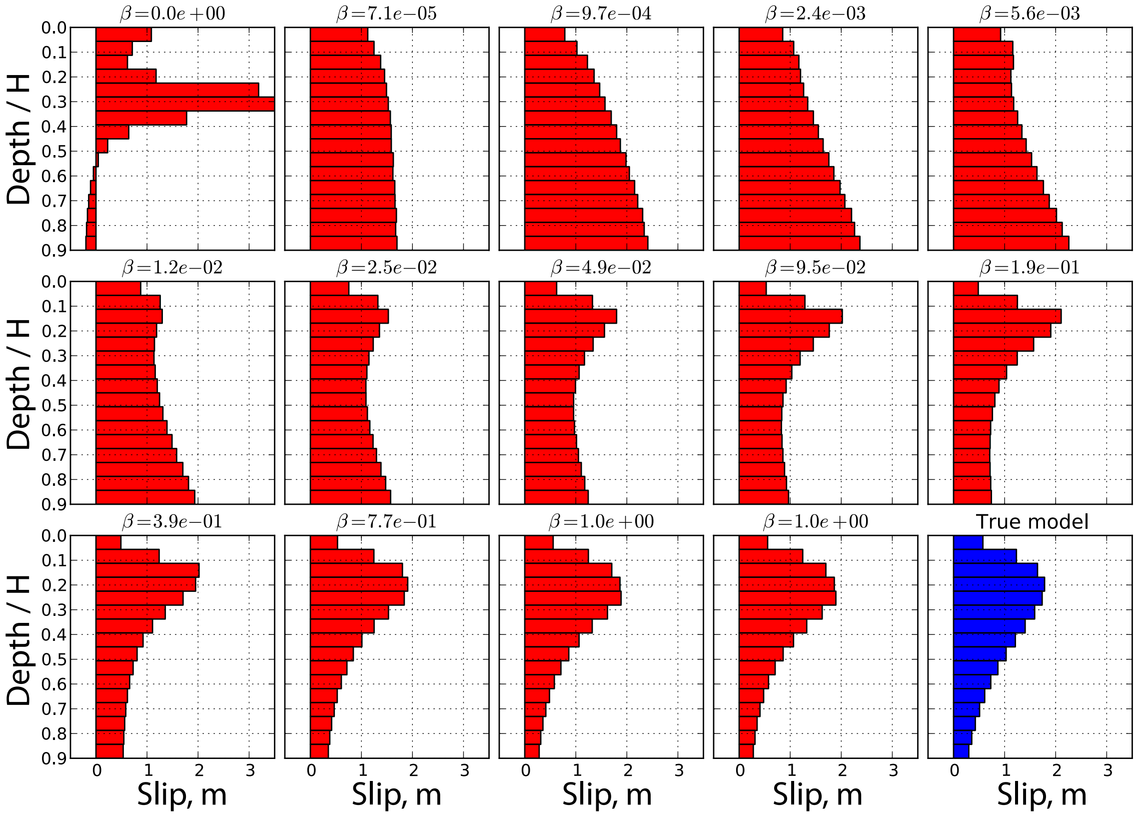

Figure S7. Slip models used for the calculation of the prediction covariance $\mathbf{C}_p$. The approach (3) described in section 4.4 of the main text is used here: the model used for the calculation of $\mathbf{C}_p$ at β=0 is the posterior mean model when $\mathbf{C}_p$ is neglected (cf., blue bars in Fig S5a). These slip models correspond to the mean of the model sample distributions at each transitional step. The values of β are specified on top of each subfigures.

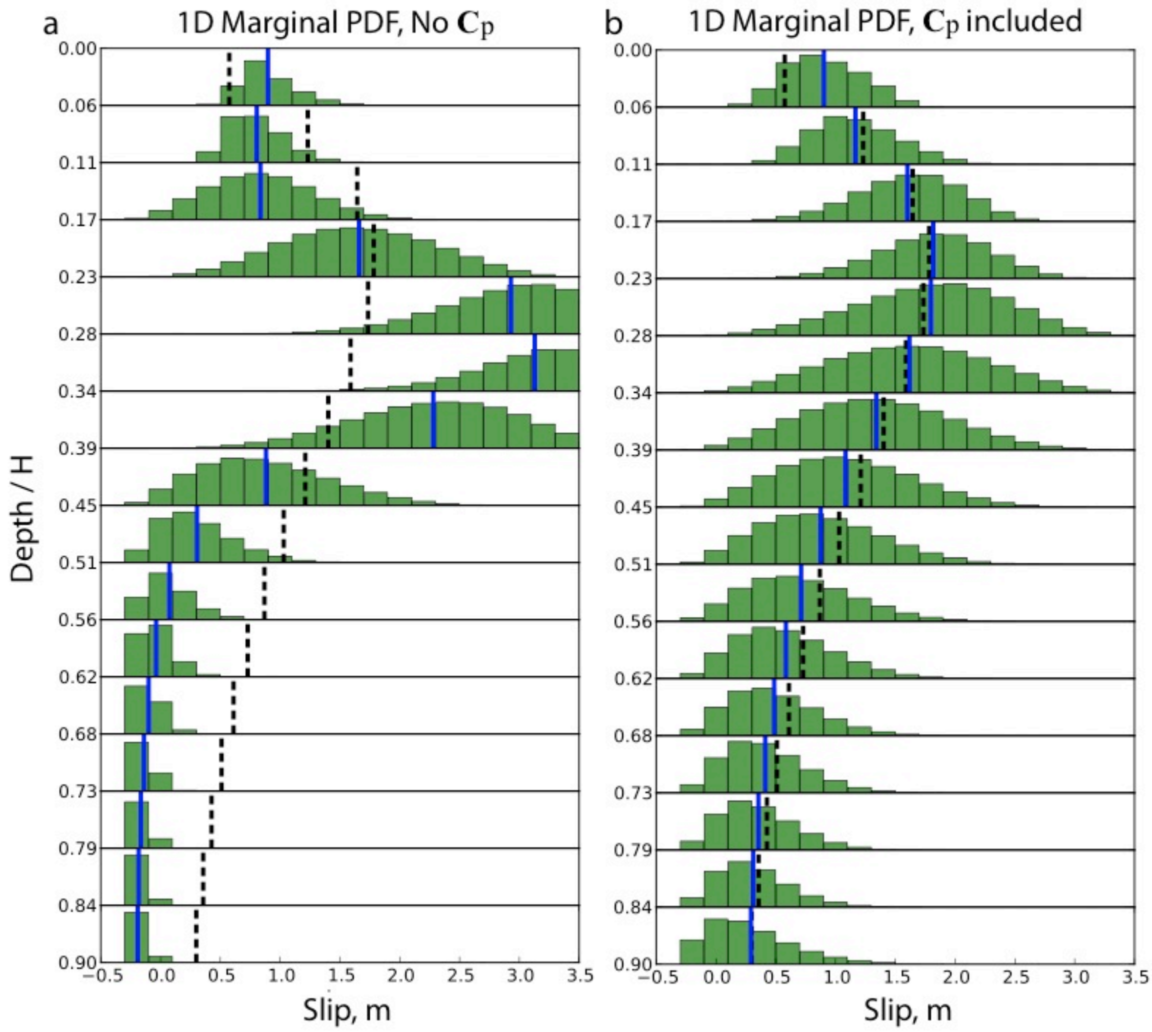

Figure S8. One-dimensional marginal posterior PDFs for each patch as a function of depth. The marginal probability density histograms are shown in green (a) when the prediction uncertainty is neglected and (b) when the prediction uncertainty is taken into account by including $\mathbf{C}_p$ in the inversion problem. The target slip model is indicated as dashed black lines and the mean of the distribution is shown in blue. The results in (b) are obtained using approach (4) described in section 4.4 of the main text: We use a preliminary form of $\mathbf{C}_p$ whose diagonal elements are proportional to observations. In this case, we assume standard deviations corresponding to 10% of observed displacement (cf., Fig. S9 at β=0).

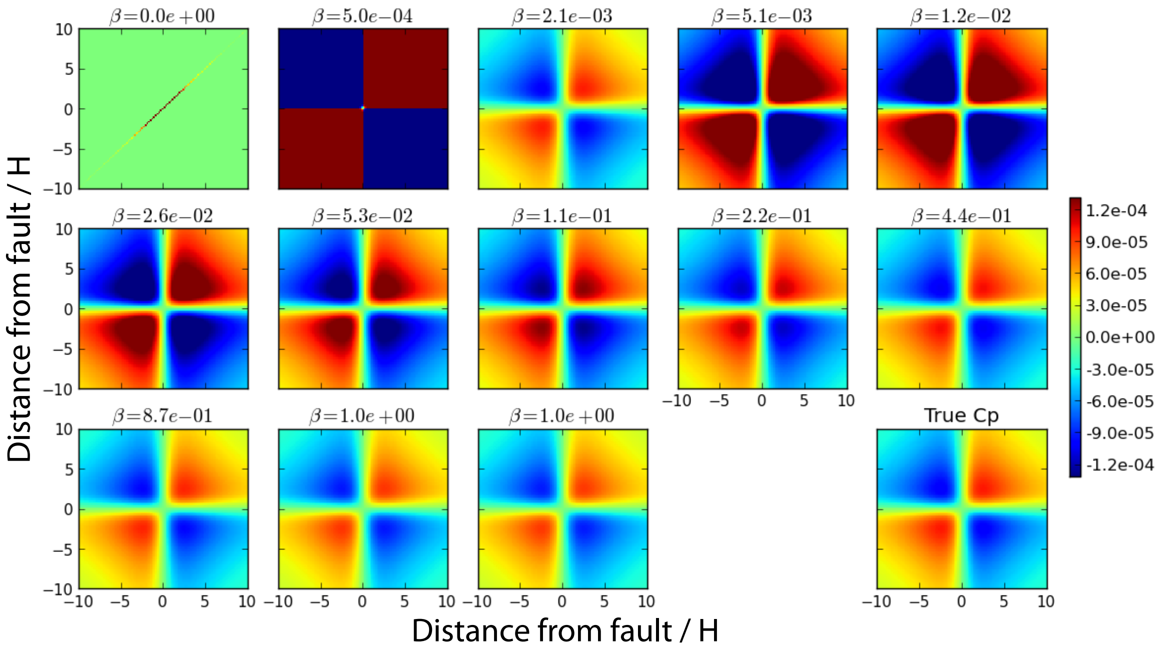

Figure S9. Evolution of the prediction covariance $\mathbf{C}_p$ at each transitional step. At β=0, we use a preliminary form of $\mathbf{C}_p$ whose diagonal elements are proportional to observations (cf., approach (4) described in section 4.4 of the main text). In this case, we assume standard deviations corresponding to 10% of observed displacement. The values of β are specified on top of each subfigures.

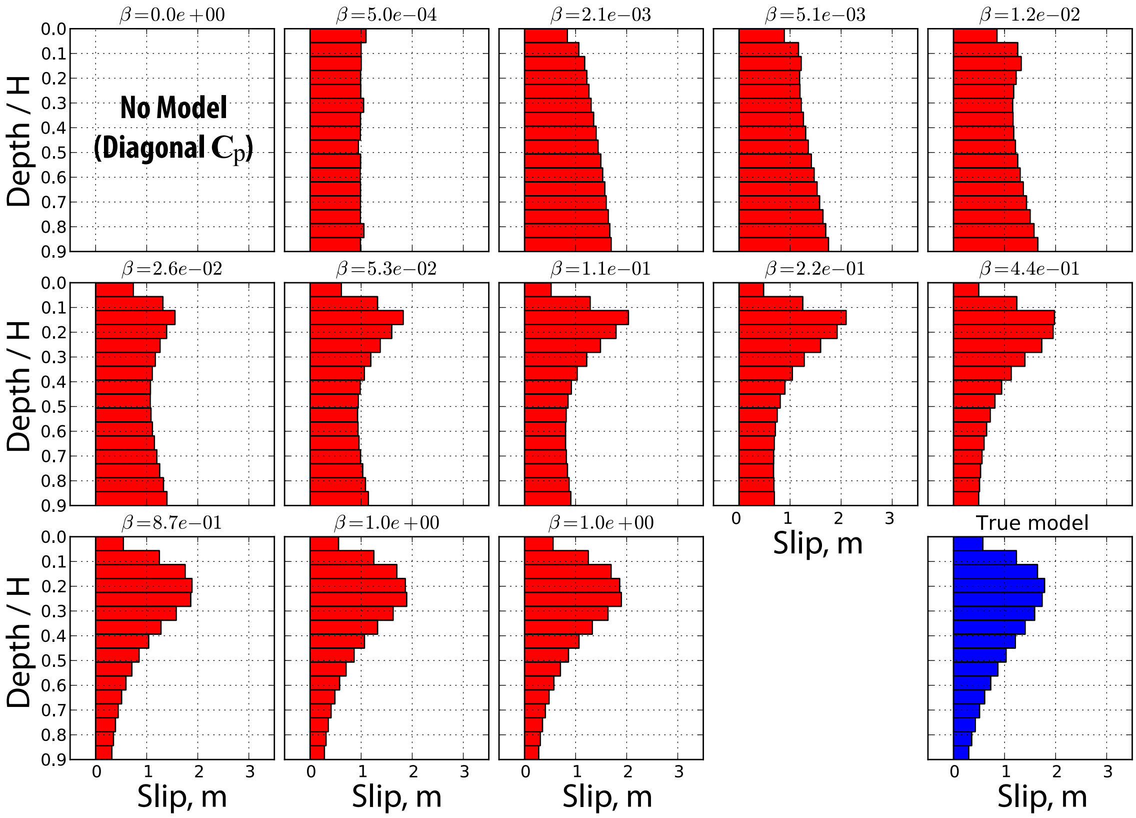

Figure S10. Slip models used for the calculation of the prediction covariance $\mathbf{C}_p$. We use a preliminary form of $\mathbf{C}_p$ whose diagonal elements are proportional to observations (cf., approach (4) described in section 4.4 of the main text). In this case, we assume standard deviations corresponding to 10% of observed displacement (cf., Fig. S9 at β=0). These slip models correspond to the mean of the model sample distributions at each transitional step. The values of β are specified on top of each subfigures.

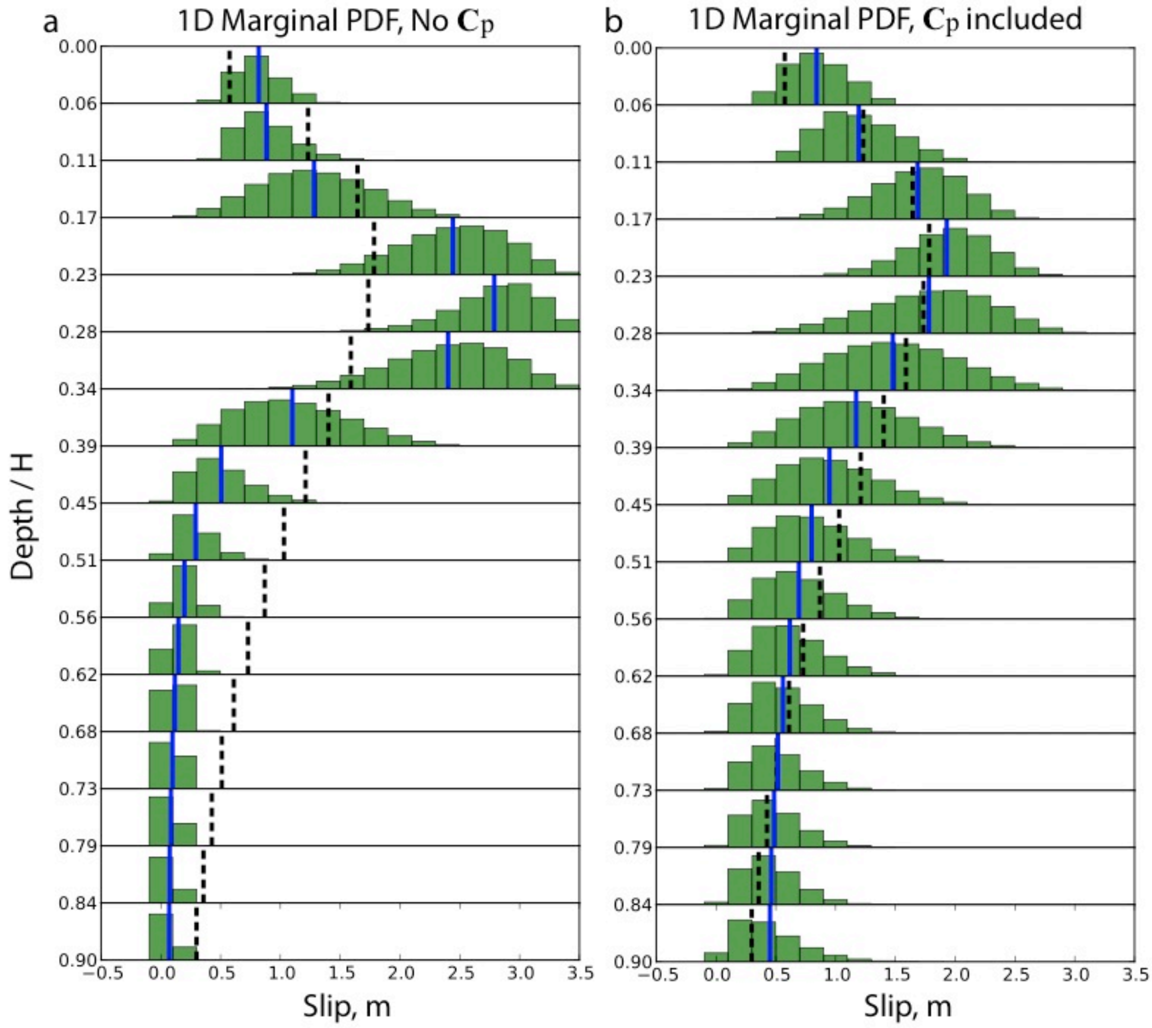

Figure S11. Same as Fig. 7 in the main text but using strictly positive constraints with a prior $p(\mathbf{m}) = U(0,20)^M$.